The Environment is a Paediatric Issue

Dr. David Githanga
CEH Symposium
Mombasa 25 April 2018
Depiction of children
Egypt – 3300 years ago
Akhenaten and Nefertiti and their 3 daughters
PARADIGM SHIFT

Children are more susceptible

Nuclear weapons tests in 1954 on Bikini Island in the South Pacific

Errant fallout caused thyroid cancer
3 cancers among 35 children < 15 years
2 cancers among 46 persons ≥ 15 years

First evidence that child’s thyroid gland especially vulnerable to ionizing radiation
1. DIFFERENT AND UNIQUE EXPOSURES

- **Unique exposure pathways**
  - Transplacental
  - Breastfeeding

- **Exploratory behaviours leading to exposures**
  - Hand-to-mouth, object-to-mouth
  - Non-nutritive ingestion

- **Stature and living zones, microenvironments**
  - Location – lower to the ground
  - High surface area to volume ratio

- **Children do not understand danger**
  - Sent by adults into risky small spaces
    - Adolescent chimney sweeps
1. DIFFERENT AND UNIQUE EXPOSURES

TRANSPLACENTAL

Lessons from pharmaceuticals: thalidomide, diethylstilbestrol (DES)

- Many chemicals cross the placenta
  - Lead, mercury, PCBs…
  - Substances of abuse: alcohol
- Some physical factors may affect the fetus directly
  - Ionizing radiation
1. DIFFERENT AND UNIQUE EXPOSURES

BREASTFEEDING

- Breast milk is the safest and most complete nutrition for infants
  - Milk (human, cow, sheep) can be a marker of environmental contamination

- DDT, DDE, PCBs, TCDD (dioxins), nicotine, lead, methylmercury, alcohol

WHO
1. DIFFERENT AND UNIQUE EXPOSURES
BEHAVIOUR AND SOIL CONSUMPTION

![Bar graph showing different exposures for children and adults. The y-axis represents mg/day, and the x-axis represents US EPA.]

- Child (mean)
- Child (upper percentile)
- Adult
1. DIFFERENT AND UNIQUE EXPOSURES

STATURE AND BREATHING ZONES

- child zone (25 cm)
- adult zone (100 cm)

Guzelian, ILSI, 1992
Adjusted* Odds Ratios and 95% Confidence Intervals for Childhood Acute Lymphoblastic Leukemia in Relation with Maternal Frequency of Use† of Pesticides in the Garden, the Yard, and on Interior Plants

<table>
<thead>
<tr>
<th>Type of Pesticides</th>
<th>Controls (N)</th>
<th>Cases (N)</th>
<th>OR</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Herbicides</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No exposure</td>
<td>417</td>
<td>369</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>1–5 times</td>
<td>66</td>
<td>112</td>
<td>1.83</td>
<td>1.31–2.57</td>
</tr>
<tr>
<td>&gt;5 times</td>
<td>2</td>
<td>6</td>
<td>3.72</td>
<td>0.72–19.06</td>
</tr>
<tr>
<td>Plant insecticides</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No exposure</td>
<td>444</td>
<td>412</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>1–5 times</td>
<td>34</td>
<td>60</td>
<td>1.89</td>
<td>1.20–2.97</td>
</tr>
<tr>
<td>&gt;5 times</td>
<td>3</td>
<td>12</td>
<td>4.01</td>
<td>1.12–14.32</td>
</tr>
<tr>
<td>Products against trees</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No exposure</td>
<td>451</td>
<td>425</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>1–5 times</td>
<td>36</td>
<td>56</td>
<td>1.65</td>
<td>1.07–2.54</td>
</tr>
<tr>
<td>&gt;5 times</td>
<td>2</td>
<td>6</td>
<td>3.27</td>
<td>0.64–16.69</td>
</tr>
<tr>
<td>Repellents and sprays against outdoor insects</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No exposure</td>
<td>427</td>
<td>443</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>1–5 times</td>
<td>24</td>
<td>16</td>
<td>0.47</td>
<td>0.21–1.05</td>
</tr>
<tr>
<td>&gt;5 times</td>
<td>15</td>
<td>17</td>
<td>1.06</td>
<td>0.52–2.13</td>
</tr>
</tbody>
</table>

*Adjusted for maternal age and maternal level of schooling; Cases and controls are matched for age, sex, and geographical region.
†Exposure of the mother from 1 month before pregnancy to the end of pregnancy.
1. DIFFERENT AND UNIQUE EXPOSURES

CHILDREN / ADOLESCENTS DO NOT RECOGNIZE DANGER

- Pre-ambulatory children are unable to remove themselves from danger
- Pre-reading children cannot read warning signs & labels
- Pre-adolescent / adolescent children put at risk because of small size (chimney sweeps)
2. DYNAMIC DEVELOPMENTAL PHYSIOLOGY

Xenobiotics may be handled differently by an immature body

- Increased energy, water and oxygen consumption of anabolic state
- Absorption
- Biotransformation
- Distribution
- Elimination
- Critical windows of development

WHO
2. DYNAMIC DEVELOPMENTAL PHYSIOLOGY

OXYGEN DEMAND

Minute ventilation per kg body weight/day

# Table II - Rate Ratios for Estimated Exposure to Benzene

<table>
<thead>
<tr>
<th>Benzene (μg/m³)</th>
<th>Cases</th>
<th>Controls</th>
<th>RR (^1) (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;0.1</td>
<td>88</td>
<td>399</td>
<td>1 (^2)</td>
</tr>
<tr>
<td>0.1–10</td>
<td>25</td>
<td>73</td>
<td>1.51 (0.91–2.51)</td>
</tr>
<tr>
<td>≥10</td>
<td>7</td>
<td>8</td>
<td>3.91 (1.36–11.27)</td>
</tr>
<tr>
<td>Totals</td>
<td>120</td>
<td>480</td>
<td></td>
</tr>
</tbody>
</table>

\(^1\) Evaluated by conditional logistic regression. \(^2\) Reference category.
2. DYNAMIC DEVELOPMENTAL PHYSIOLOGY

CALORIE AND WATER NEEDS

<table>
<thead>
<tr>
<th>Age in Years</th>
<th>Maintenance Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;1</td>
<td>1.0-3.0</td>
</tr>
<tr>
<td>1.0-3.0</td>
<td>4.0-6.0</td>
</tr>
<tr>
<td>4.0-6.0</td>
<td>7.0-10.0</td>
</tr>
<tr>
<td>7.0-10.0</td>
<td>11.0-14</td>
</tr>
<tr>
<td>11.0-14</td>
<td>15-18</td>
</tr>
<tr>
<td>15-18</td>
<td>19-24</td>
</tr>
<tr>
<td>19-24</td>
<td>25-50</td>
</tr>
<tr>
<td>25-50</td>
<td>50+</td>
</tr>
</tbody>
</table>

![Graph showing calorie and water needs across different age groups](image-url)
2. DYNAMIC DEVELOPMENTAL PHYSIOLOGY

**ABSORPTION**

- A child is building a “body for a lifetime”

- The demands of rapid growth and development
  - Require higher breathing rate, caloric and water intakes
  - Satisfied by enhanced absorption and retention of nutrients

For example:

- GI absorption of lead in toddler: 40–70% of oral dose (1/3 retention)
- GI absorption of lead in non-pregnant adult: 5–20% (1% retention)
Schematic illustration of the sensitive or critical periods in human development. Red denotes highly sensitive periods; yellow indicates stages that are less sensitive to teratogens.

Table 8 Variations with age of radiation risk (RR) for thyroid cancer (after exposure to 1 Gy) (thyroid weights: birth 1 g, 6 months 2 g, 4 years 4 g, 10 years 20 g, 18 years 20 g; NS not significant)

<table>
<thead>
<tr>
<th>Patients [21]</th>
<th>Survivors of Hiroshima and Nagasaki [101]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>RR</td>
</tr>
<tr>
<td>0–4 years</td>
<td>40</td>
</tr>
<tr>
<td>5–9 years</td>
<td>20</td>
</tr>
<tr>
<td>10–14 years</td>
<td>10</td>
</tr>
<tr>
<td>20–30 years</td>
<td>1</td>
</tr>
<tr>
<td>&gt;30 years</td>
<td>0</td>
</tr>
</tbody>
</table>
INFANT ACUTE PULMONARY HEMORRHAGE

- Lungs continue growing rapidly in 1\textsuperscript{st} year of life
- Exposures to molds in homes is association with acute lung bleeding
- Mycotoxins on surface of mold spores lead to capillary fragility
- 10% fatal

Alimentary Toxic Aleukia (ATA)

- First appeared in 1913 in far eastern Siberia
- Responsible for the death of at least 100,000 Russian people between 1942 and 1948
- Necrotic ulcers in the mouth, throat, nose, stomach and intestines
- Bleeding from the nose, mouth, GI tract, and kidneys
- Associated with eating grains (wheat and corn) which had been under snow the previous winter
- Grains contaminated with *Fusarium* and *Stachybotrys*
Fathers and their Offspring

Occupational exposures – suggestive evidence

- **Paint, solvents**
  - germ cell tumors
  - hepatic tumors
  - brain and CNS tumors
  - acute lymphoblastic leukaemia

- **Welder**
  - renal tumors
  - retinoblastoma
Fathers and their Offspring

Occupational exposures – suggestive evidence

• Petroleum
  - acute lymphoblastic leukaemia
  - brain and CNS tumors
  - hepatic tumors

• Paper or pulp mill
  - brain tumors
## Paternal Smoking and Childhood Cancer

<table>
<thead>
<tr>
<th>Cancer</th>
<th>Relative Risk</th>
<th>Cl, p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rhabdomyosarcoma</td>
<td>3.9</td>
<td>p=0.003</td>
</tr>
<tr>
<td>Brain</td>
<td>2.0</td>
<td>1.0-4.1</td>
</tr>
<tr>
<td>Infant leukemia</td>
<td>1.56</td>
<td>1.03-2.36</td>
</tr>
<tr>
<td>All types (1953-55)</td>
<td>1.89 highest tertile</td>
<td>0.84-4.24, p=.001</td>
</tr>
<tr>
<td>All types (1971-76)</td>
<td>1.63 highest quintile</td>
<td>1.23-2.15, p=.001</td>
</tr>
<tr>
<td>All types</td>
<td>1.7 highest tertile</td>
<td>1.2-2.5, p=.006</td>
</tr>
<tr>
<td>ALL</td>
<td>3.8 highest tertile</td>
<td>1.3-12.3, p=.01</td>
</tr>
<tr>
<td>Lymphoma</td>
<td>4.5 highest tertile</td>
<td>1.2-16.8, p=.07</td>
</tr>
<tr>
<td>Brain</td>
<td>2.7 highest tertile</td>
<td>0.8-9.99, p=.14</td>
</tr>
<tr>
<td>All types</td>
<td>1.77 highest quintile</td>
<td>0.94-3.34, p=.02</td>
</tr>
<tr>
<td>Astroglial</td>
<td>1.4</td>
<td>1.1-1.9</td>
</tr>
</tbody>
</table>
2. DYNAMIC DEVELOPMENTAL PHYSIOLOGY

WINDOWS OF DEVELOPMENT: MOTHERS AND THEIR OFFSPRING

_In utero_  
- Thalidomide $\rightarrow$ phocomelia  
- DES $\rightarrow$ vaginal cancer  
- X-rays $\rightarrow$ leukaemia
3. LONGER LIFE EXPECTANCY

- Exposures early in life permit manifestation of environmental illnesses with long latency periods
  - More disease
  - Longer morbidity
EARLY CHILDHOOD EXPOSURES

predisposing to adult cancer

1. Ionizing radiation
   → breast cancer, ALL, thyroid cancer
2. Radiotherapy for Hodgkin’s disease
   → osteosarcoma, leukaemia, skin cancer,
   breast cancer, soft tissue sarcoma
3. UV sunlight
   → melanoma, basal and squamous cell carcinomas
4. Tobacco
5. Asbestos
6. Diet - fats and aflatoxins
   → Cancer of colon, breast, and liver
4. POLITICALLY POWERLESS

- No political voice
- Advocacy by health sector
- Environmental laws and regulations
  - Local
  - National
  - International

(by Ceppi and Corra)
CHILDREN ARE NOT LITTLE ADULTS

1. Different and unique exposures
2. Dynamic developmental physiology
3. Longer life expectancy
4. Politically powerless
Radiofrequency (RF) Fields

So far no certainty, but …

• Children's exposure is different
  – Behaviour
  – Timing of exposure
  – Duration of exposure

• Children's anatomy and physiology is different
  – Head size (% of brain exposed)
  – Skull thickness
  – Ear elasticity

• So research is ongoing…
“green behind the ears”
“green between the ears”
Why paediatricians and nurses should care about the environmental determinants of health

- Many children with illnesses caused by environmental contamination are not recognized as such
- The child that you diagnose often represents the tip of the iceberg
- By taking action you can prevent or reduce illness in others in the community
- Need for policies to protect children